Soil Biology & Biochemistry 88 (2015) 148–157

Contents lists available at ScienceDirect

Soil Biology & Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Loss of labile organic carbon from subsoil due to land-use changes in subtropical China

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A R T I C L E I N F O

Article history:
Received 27 November 2014
Received in revised form
14 May 2015
Accepted 16 May 2015
Available online 2 June 2015

Keywords:
Subsoil carbon
Soil organic matter
Permanganate oxidation
Chloroform fumigation
Land degradation
Deforestation
Agricultural management practices

A B S T R A C T

Topsoil carbon (C) stocks are known to decrease as a consequence of the conversion of natural ecosystems to plantations or croplands; however, the effect of land use change on subsoil C remains unknown. Here, we hypothesized that the effect of land use change on labile subsoil organic C may be even stronger than for topsoil due to upward concentration of plantations and crops root systems. We evaluated soil labile organic C fractions, including particulate organic carbon (POC) and its components [coarse POC and fine POC], light fraction organic carbon (LFOC), readily oxidizable organic carbon, dissolved organic carbon (DOC) and microbial biomass down to 100 cm soil depth from four typical land use systems in subtropical China. Decrease in fine root biomass was more pronounced below 20 cm than in the overlying topsoil (70% vs. 56% for plantation and 62% vs. 37% for orchard. respectively) driving a reduction in subsoil labile organic C stocks. Land use changes from natural forest to Chinese fir plantation, Chinese chestnut orchard, or sloping tillage reduced soil organic C stocks and that of its labile fractions both in top and subsoil (20–100 cm). POC reduction was mainly driven by a decrease in fine POC in topsoil, while DOC was mainly reduced in subsoil. Fine POC, LFOC and microbial biomass can be useful early indicators of changes in topsoil organic C. In contrast, LFOC and DOC are useful indicators for subsoil. Reduced proportions of fine POC, LFOC, DOC and microbial biomass to soil organic C reflected the decline in soil organic C quality caused by land use changes. We conclude that land use changes decrease C sequestration both in topsoil and subsoil, which is initially indicated by the labile soil organic C fractions.

1. Introduction

Land use and land use changes (LULUC) in tropical and subtropical areas, including forest conversion, capitalized agricultural intensification and animal husbandry expansion, represent major anthropogenic contributions to greenhouse gas emissions (Harris et al., 2012; IPCC, 2013). Tropical and subtropical Asia concentrates the fastest and most dramatic LULUC in the world, mainly as consequences of rapid agricultural expansion and increasing population pressure (Houghton, 2002; Carlson et al., 2012). The average rate of deforestation in tropical Asia during the 1990s reached up to 5.6×10^6 ha yr^{-1}, resulting in the emission of 1.0 Pg C yr^{-1} into the atmosphere (Houghton, 2002).

Tropical and subtropical aboveground biomass has received much research attention because these regions are highly productive with dense C stocks (Lewis et al., 2009; Huntingford et al., 2013). However, comprehensively studies regarding underground soil organic C (SOC) content and fractions, lability and response to land use change remain scarce.

Highly weathered tropical and subtropical soils present the deepest profiles and largest volumes among soils worldwide, accounting for nearly half of the global soil C stock in the top 3 m of soil (Richter and Markewitz, 1995; Jobbágy and Jackson, 2000). Unfortunately, most studies on the effect of LULUC on SOC have focused on the topsoil layer (0–20 cm) being the layer of soil containing the highest levels of SOC and the greatest microbial

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http://dx.doi.org/10.1016/j.soilbio.2015.05.015